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Taking the Next Steps: The Ares I Crew Launch Vehicle and Ares V Cargo Launch Vehicle

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Abstract

The National Aeronautics and Space Administration (NASA)'s Constellation Program is depending on the Ares Projects Office (APO) to deliver the crew and cargo launch capabilities needed to send human explorers to the Moon, Mars, and beyond. The APO continues to make progress toward design, component testing, and early flight testing of the Ares I crew launch vehicle, as well as early design work for the Ares V cargo launch vehicle. Ares I and Ares V will form the core space launch capabilities that the United States needs to continue its pioneering tradition as a spacefaring nation (Figure 1). This paper will discuss design, fabrication, and testing progress toward building these new launch vehicles.

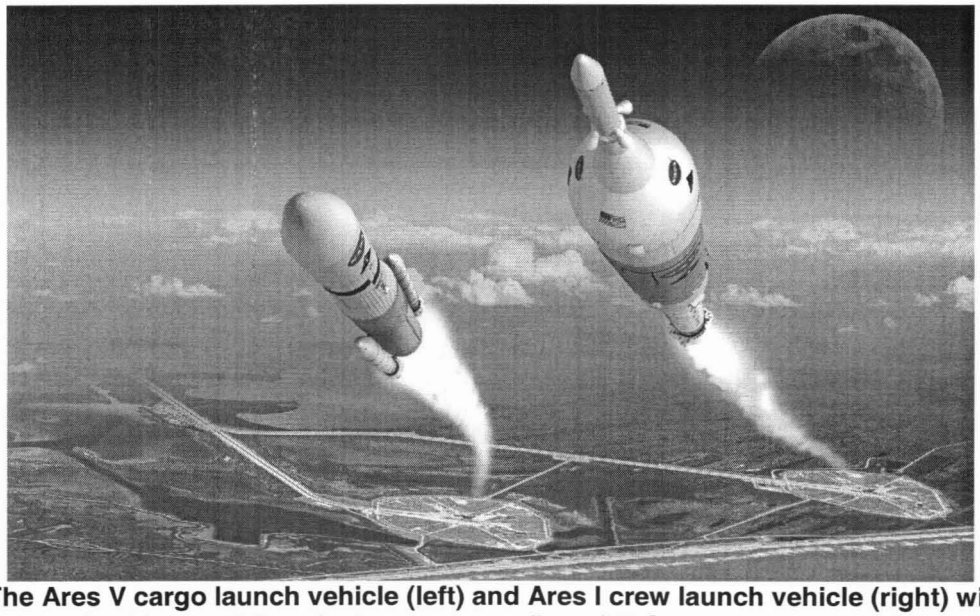

Figure 1. The Ares V cargo launch vehicle (left) and Ares I crew launch vehicle (right) will form the backbone of America's new space fleet. (NASA artist's concept)

Programmatic Progress

In 2007 the Ares I crew launch vehicle successfully passed its Systems Definition Review (SDR). This year will be just as eventful for the APO. The Ares I Preliminary Design Review (PDR) in July will demonstrate that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. It will show that the correct design option has been selected, interfaces have been identified, and verification methods have been described.[1] This year the flight test vehicle for the Ares I-X suborbital test flight will undergo its Critical Design Review (CDR) in March. Assuming a successful conclusion to the CDR, the Ares I-X Mission Management Office will begin delivery flight hardware to Kennedy Space Center (KSC) in August 2008 for an April 2009 launch.

First Stage

In June 2007, the first stage team completed a trade study regarding the use of metal versus composite materials for the new forward structures: the forward skirt, forward skirt extension, frustum, and aeroshell. The study focused on reusability, ease of manufacture, structural durability, and weight.

ATK Launch Systems and their subcontractors are building the first Development Motor, which will be tested in April 2009. Other elements of the First Stage Element Office are building and testing larger parachutes for the First Stage recovery system.

Upper Stage

The Ares I upper stage instrument unit was awarded in December 2007. With a contractor partner aboard for the entire NASA-designed upper stage and instrument unit, the prime contractor has begun development and production work in earnest.

The Upper Stage team also began orthogrid panel structural buckling tests, which expand on earlier testing done on Space Shuttle External Tank orthogrid panels.

Upper Stage Engine

For Ares I, the J-2X upper stage engine is being designed to start at altitude and operate for approximately 500 seconds to put the upper stage and Orion into orbit. For Ares V, the J-2X will start at altitude, operate for roughly 500 seconds to place the earth departure stage (EDS) and lunar lander into orbit, shut down for up to 95 days, and then restart for about 300 seconds to execute trans-lunar injection (TLI) before final shutdown.

The first J-2X powerpack test series began in December 2007 on the A-1 test stand at Stennis Space Center (Figure 2).

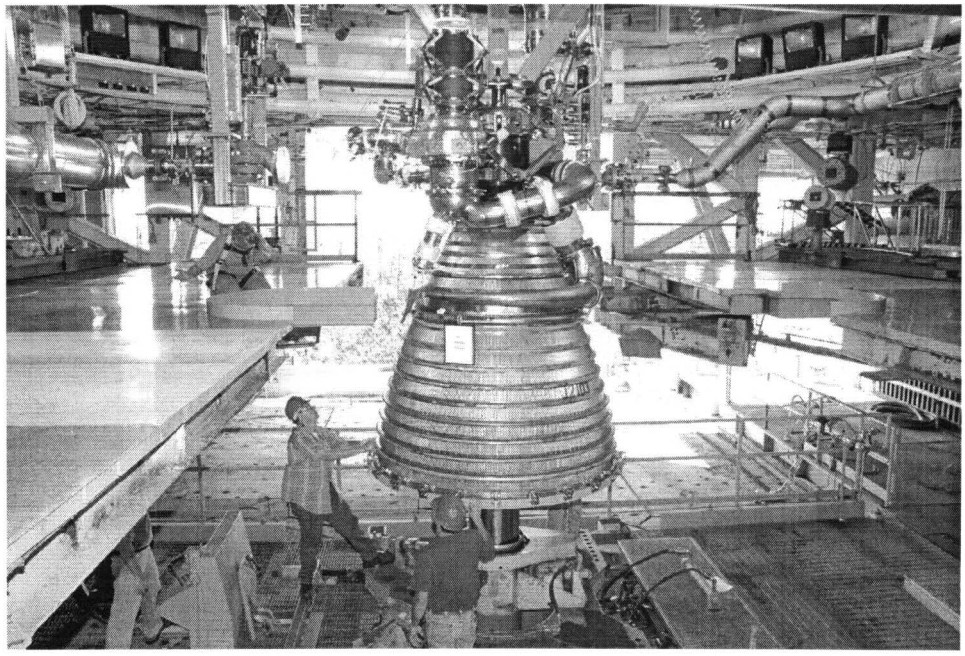

Figure 2. Powerpack 1A during test stand installation at Stennis Space Center.

Ares I-X Flight Test

As stated earlier, the Ares I-X mission in April 2009 will be the first flight of the Ares I crew launch vehicle. With element and vehicle CDRs planned for early 2008, the Ares I-X Mission Management Office is still on track to meet its 2009 launch date.

Launched top a four-segment Reusable Solid Rocket Booster (RSRB) from the Space Shuttle inventory, the Ares I-X flight test vehicle (FTV) will comprise both operational flight hardware and simulator hardware. The Command Module and Launch Abort System (CM/LAS) simulators are being built at Langley Research Center in Virginia. The Upper Stage Simulator (USS) is being designed and built at Glenn Research Center in Ohio. The USS is being built in a series of 11 smaller "tuna can" segments, which will be stacked and integrated at Kennedy Space Center in Florida. In addition to this hardware, the new forward structures connecting the First Stage to the Upper Stage—empty fifth segment, forward skirt, forward skirt extension, and frustum—are being fabricated.

The FTV on the interstage will have an active roll control system (RoCS) recovered from Peacekeeper missiles to keep the vehicle from rolling. The RoCS also initiates a 90-degree roll soon after liftoff to properly orient the FTV for flight.

The Ares I-X avionics system will use a combination of avionics components from the Atlas V Evolved Expendable Launch Vehicle (EELV) and heritage Space Shuttle systems. The work receiving the most attention at present is the only new piece of avionics on the Ares I-X mission, the ascent thrust vector controller (ATVC) system, which acts as a translation tool between liquid-fuel and solid-fuel rocket systems.

Ares V Cargo Launch Vehicle

NASA has begun preliminary concept work on the Ares V cargo launch vehicle. Much of that work has been focused on the design of the core stage and the Pratt & Whitney Rocketdyne RS-68 core stage engine. MSFC is continuing trade studies on the Ares V design, including the optimum shape and size of the composite payload shroud. The size of the shroud will be dictated by the eventual size of the lunar lander, which is still under development by the Lunar Architecture Team. Full-scale Ares V design and development work is scheduled to begin after the Space Shuttle has been retired at the end of 2010.

Summary

With the first flight test in 2009 and additional tests and development in work, the Ares launch vehicles continue on schedule to fulfill this strategic capability for the future. APO is making great strides toward building a safe, reliable, efficient new generation of launch vehicles to support International Space Station (ISS) operations and—most importantly—human exploration of the Moon, Mars, and other destinations.

Nomenclature

APO = Ares Projects Office
ASA = Altitude Switch Assembly
ATVC = Ascent Thrust Vector Controller
BDM = Booster Deceleration Motor
BTM = Booster Tumble Motor
CaLV = Cargo Launch Vehicle)
CDR = Critical Design Review
CEV = Crew Exploration Vehicle
CLV = Crew Launch Vehicle
CM/LAS = Command Module/Launch Abort System (simulator)
CP = Cylindrical Port
DAC = Design Analysis Cycle
DDT&E = Design, Development, Test, and Evaluation
DFI = Developmental Flight Instrumentation
DM = Development Motor
DTV = Drop Test Vehicle
EDS = Earth Departure Stage
EELV = Evolved Expendable Launch Vehicle
ELP = Exploration Launch Projects
ESAS = Exploration Systems Architecture Study
ETR = Eastern Test Range
FCDC = Flexible Confined Detonating Cord
FITO = Flight and Integrated Test Office
FS = first stage
FSE = Forward Skirt Extension
FSM = Flight Support Motor
ft. = Feet
FTINU = Flight Test Inertial Navigation Unit
FTS = Flight Termination System
GN&C = Guidance, Navigation, and Control
IS = Interstage
ISS = International Space Station
JSC = Johnson Space Center
k = Thousand
Klbf. = Thousands of Pounds of Force
KSC = Kennedy Space Center
LAS = Launch Abort System
LH_2 = Liquid Hydrogen
LOC = Loss of Crew
LOM = Loss of Mission
LOX = Liquid Oxygen
LSC = Linear Shaped Charge
MAF = Michoud Assembly Facility
Max G = Maximum Gravity
Max Q = Maximum Dynamic Pressure
MEOP = Maximum Expected Operating Pressure
Mlbf-sec = Million pounds of force per second
MMO = Mission Management Office
MPSS = Main Parachute Support System
MSFC = Marshall Space Flight Center
mT = Metric Ton (Tonne)
NASA = National Aeronautics and Space Administration
PBAN = Polybutadiene Acrylonitrile
PDR = Preliminary Design Review
PFI = Post Flight Inspection
PSA = Production Simulation Article
psf = Pounds per square foot
psi = Pounds per square inch
RoCS = Roll Control System
RSRB = Reusable Solid Rocket Booster
SDR = System Design Review
sec = Seconds
SOMD = Space Operations Mission Directorate
SRM = Solid Rocket Motor
SSME = Space Shuttle Main Engine
SW = Space Wing
TLI = Trans-Lunar Injection
TPS = Thermal Protection System
TVC = Thrust Vector Control
US = Upper Stage
USE = Upper Stage Engine
USS = Upper Stage Simulator
V&V = Validation and Verification

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[1] National Aeronautics and Space Administration. *NPR 7123.1 System Engineering Processes and Requirements.* March 13, 2006.